CircuitClarity RESOURCE

Reliability, lifetime, FIT, and acceleration models

https://circuitclarity.com/resources/reliability-and-lifetime-models/

The decision this guide supports

Reliability metrics and life estimates are not interchangeable. A constant FIT model describes a population rate, an Arrhenius factor compares a stated stress mechanism, and a capacitor life rule only applies under its named data-sheet conditions.

A useful calculation is not the finish line. It becomes useful when its method, units, source conditions, and omitted effects fit the actual design question. Use this reference to identify that boundary before treating a nominal result as an implementation decision.

DECISION MAP

From first estimate to defensible next step

1. **Name the design decision: population risk, comparative life, or accelerated-stress planning.**

   Start by naming the physical quantity, operating condition, and decision at stake. A number without that context cannot establish a design margin.

2. **Use the model whose assumptions match the selected part and mission profile.**

   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

3. **Keep temperature, voltage, ripple, activation-energy, and confidence conditions visible.**

   Keep this check explicit. It separates a useful first-pass model from an answer that only looks precise.

4. **Return to manufacturer data, qualification evidence, or measurement before a critical life claim.**

   Treat this as the handoff point. Compare the result with selected-part evidence, the real layout or assembly, and a measurement method that can reveal the remaining uncertainty.

Worked design review

Consider a designer using this method to make a first selection. The initial estimate establishes the nominal target, but it should not silently absorb a rating, curve, parasitic, temperature condition, or measurement setup from a different scenario. The correct outcome is often not a single chosen value: it is a short list of conditions that must be satisfied together.

Begin with the first two steps above, then ask whether the value still fits when the most consequential real-world condition changes. If it does, the estimate has earned a more detailed check. If it does not, the discrepancy identifies the design variable that deserves attention before a board, part, or test plan is committed.

> **Practical interpretation**
>
> These methods do not guarantee an individual lifetime, establish qualification, or replace selected-part data and validation. That is not a weakness in the method. It is the cue to use the correct next source of evidence.

Questions to take into a design review

Is the reliability metric being used (MTBF, FIT, an acceleration factor) actually answering the specific question this design decision needs, rather than whichever number was easiest to find?

Was the activation energy or acceleration model used specific to the actual failure mechanism in question, not a generic or borrowed value?

For a life-critical claim, has manufacturer qualification data or a representative measurement been checked, not just an extrapolated model?

These questions prevent a common failure mode: moving a correct equation into a context where its assumptions no longer hold. They also make it easier for another engineer to reproduce the reasoning and identify which condition needs more evidence.

Common ways this reasoning goes wrong

Quoting a population MTBF figure as an individual unit's expected lifetime

MTBF is a population-level, constant-failure-rate metric. Presenting it as "how long will my unit last" conflates a statistical population statement with an individual guarantee the number was never meant to make.

Applying an Arrhenius acceleration factor with a generic or borrowed activation energy

Acceleration factors are only meaningful for the specific failure mechanism whose activation energy was used; borrowing a convenient activation-energy value from an unrelated mechanism produces a number that looks precise but does not describe the real failure physics.

Extrapolating a manufacturer's capacitor life-doubling rule outside its stated ripple-current and voltage conditions

The rule is only validated at the rated test conditions in the data sheet; using it to extrapolate to a different ripple current or voltage than what it was characterized under is outside the model's support.

Where this guide stops

These methods do not guarantee an individual lifetime, establish qualification, or replace selected-part data and validation.

For a consequential design, preserve the inputs and conditions used here, then compare them with the selected component or system evidence. That makes the follow-up review faster and keeps a useful first estimate from becoming an unsupported claim.

Frequently asked questions

▶ **Does a 1,000,000-hour MTBF mean an individual unit will last that long?**

▶ **Can I use an Arrhenius acceleration factor for any failure mechanism?**

▶ **Why does a capacitor life-rating rule only work "under its named conditions"?**

Related engines

Electrolytic capacitor life estimator

FIT, MTBF, and reliability converter

Arrhenius acceleration factor

Method authorities and source conditions

Use this guide alongside the engine-specific method and selected component or system data. The underlying reference families are Analog Devices reliability references, TI thermal references. Those sources establish condition-specific behavior; CircuitClarity uses them to frame the decision and its limits.